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[illegible] INDICATION AS A FUNCTION OF INSTRUCTION

BY

R. L. LIPSCHULTZ

[illegible] LABORATORY

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TARGET INDICATION AS A FUNCTION OF INSTRUCTION

SUMMARY

Purpose The investigation was conducted to determine the accuracy and speed with which an operator can indicate targets under three separate sets of instructions. The search radar used was the SG-lb (Mod 50).

Instructions The following instructions were given to the five operators studied:

(a) for continuous antenna rotation; "Accuracy is most imperative, with speed secondary."

(b) for continuous antenna rotation; "Speed is most imperative, with accuracy secondary," and

(c) for stopping the antenna, "Accuracy and speed are equal in importance."

Methods Two operating methods were tested. In the first, the antenna rotated continuously (4, 6, 8, or 12 rpm) and the operators read bearings and ranges from the PPI with the help of the bearing cursor and movable electronic range ring. In the second, operators stopped the antenna on the target, read bearings from the relative bearing dial and ranges from the A-scope.

Results The results of the investigation may be summarized in six statements:

1. The principal effect of the instructions was to divide the operators into two groups, those that observed the target once (Speed-instructions) and those that observed the target two or more times (Accuracy-instructions).

2. Approximately 200 yards greater accuracy was obtained when the operator observed the target two or more times.

3. The use of two blip observations seems to give optimum accuracy and speed for any rate of antenna operation.

4. Greatest accuracy was achieved when the operators were instructed to use the stopping-of-the-antenna method.

5. The range error increased with operator speed.

6. The working time increased when greater accuracy was sought.

PURPOSE

Target indication in radar operation requires an operator to obtain and report the range and bearing of a target appearing on a PPI scope. In the past it has been observed that operators tend to be less accurate when they work faster and more accurate when they work slower. This experiment was conducted to determine how accurately, and how fast, an operator can perform target indications using different methods of operation and at different rates of antenna rotation.

In most instances a radar operator uses a mechanical cursor for bearing readings and/or a movable electronic range ring, a "range bug" for range readings. These aids are found on the SR, SG, and SP radars and on the VD and VJ remote repeaters. For the purpose of this experiment, the SG-lb Mod 50 search radar was utilized to provide a PPI viewing scope and target indication aids.

EXPERIMENTAL PROCEDURE

Two methods of operating the radar were tested. In the first method, the antenna sweep continuously rotated around the PPI. Four rates of antenna rotation were used, namely 4, 6, 8, and 12 rpm. The second method utilized the A-scope with the operator stopping the antenna on the target. Five SG operators were tested as subjects: two Navy Chief Radarmen, one Radarman Second Class, and two ex-radarmen. All subjects had a number of years' experience with the operation of radar equipment.

The SG operators were permitted to operate the equipment in their usual manner. However, the specific instructions regarding accuracy or speed were presented to them before each trial. Practice runs were given before experimental data were recorded in order to minimize the effect of learning. The SG operators were also thoroughly briefed in the specific instruction before each run.

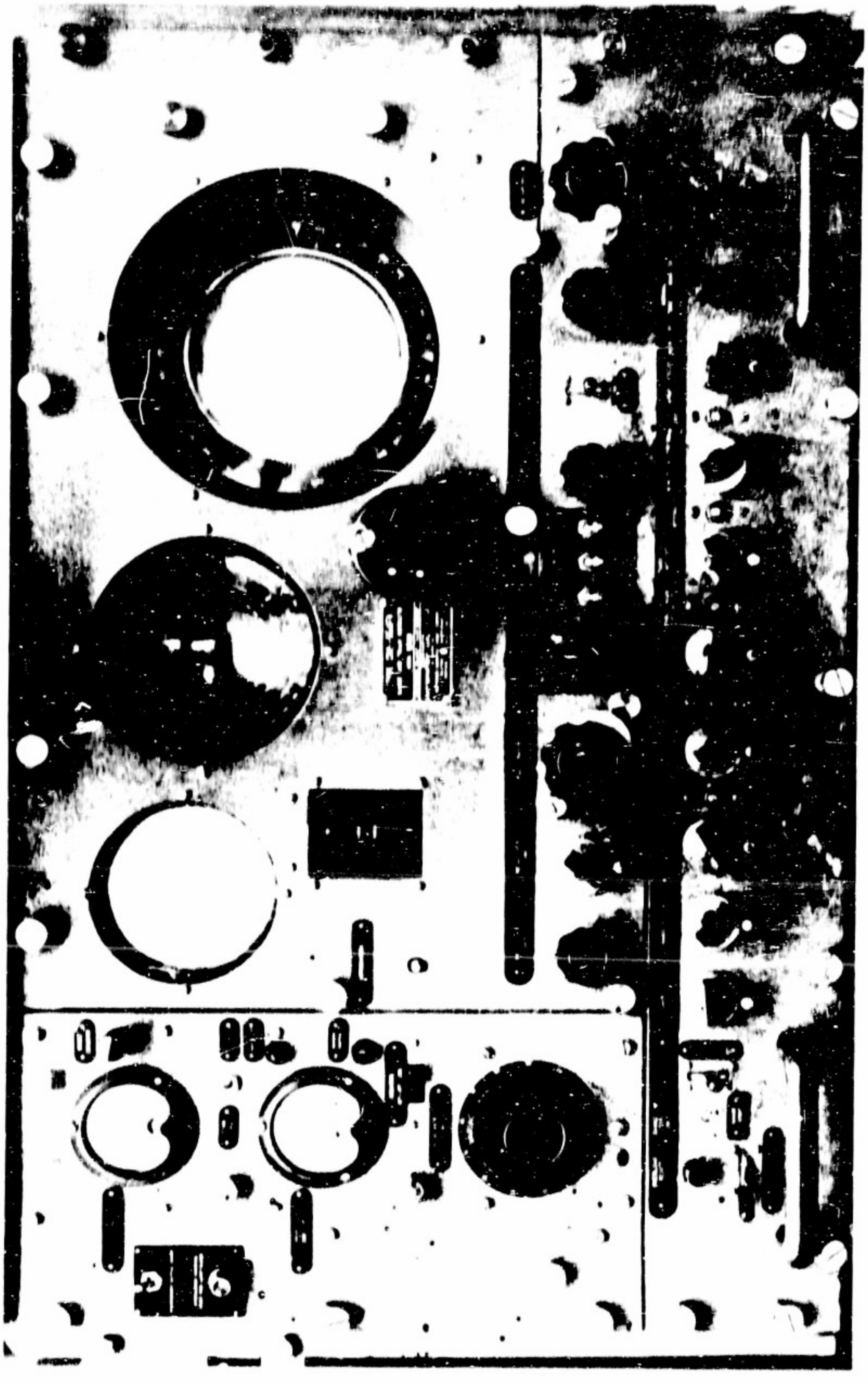

Fig. 1. Console panel of the SG-1b (Mod 50)

Specific Instructions to SG Operators

For those trials when the antenna was in continuous rotation, the instructions were:

Accuracy-Instructions (Run I):

"Accuracy is most imperative. Speed is secondary. You should be absolutely certain that you have obtained the most accurate reading possible, without actually stopping the antenna rotation. If you feel that you should wait for the sweep to cross the target again, do so. If you believe that you will obtain a more accurate reading, and that it is not necessary to bisect the target with the range trace, you need not do so unless you feel that bisecting the pip will give you a more accurate reading or one of which you are more certain."

Speed-Instructions (Run II):

"Speed is most imperative. Accuracy is secondary. You should make all possible efforts to get on the target as fast as possible and report the range and bearing immediately. You may be forced into a certain amount of idleness while waiting for a new target, so do not be disturbed about this waiting period, as this will not be included as part of the measurements. The range trace need not be passed through the pip, but you should use your own judgment to the fullest extent insofar as estimating the range reading."

After the SG operator completed the two runs at different rates of antenna rotation, he was given new instructions to operate the SG by stopping the antenna and using the A-scope (range scope) to obtain an accurate range. The bearing reading was obtained from the "bug" on the Relative Bearing dial. The specific instructions to the operator were:

A-Scope Instructions (Run III)

"Obtain and report an accurate reading on range and bearing as fast as possible."

General Instructions to Operators

In addition to the above specific operating instructions each SG operator was given a set of general instructions which held for all experimental runs. The instructions were:

The operating adjustments shall be made by the individual SG operator. This includes focus, gain control, dial illumination, etc.

The operator shall hold both hands on bearing and range dials continuously.

The operator does not need to press the button on the sound-powered telephone in order to speak because it will be hooked up on a continuous circuit.

In some instances, the SG operator will be idle while waiting for the next target. However, the operator should not move the dial settings from the last position until the sweep uncovers a new target. The next target can appear on either side of the old target, so that the operator must be alert at all times.

Methods of SG Operation For continuous antenna rotations, (Runs I and II), all five SG operators used essentially the same method of operating the equipment. The operator first centered his visual attention on the PPI scope, and upon observing the target, advanced or decreased the range trace until it was as close to the center of the target as possible. When the operator had been instructed to obtain very accurate readings, he usually waited until the PPI trace crossed the target as many times as he believed necessary for an accurate range reading. When speed was wanted, the operator viewed the target only once and then adjusted the range trace as closely as possible to the target. The operator then brought the bearing cursor over the target and adjusted it until the cursor split the target. The operator then read the bearing in degrees from the scale on the PPI, shifted his eyes to the range counter, and reported the range reading. After making the report, the operator held his hands stationary on the bearing and range cranks and continued his visual scanning until the next target appeared in a different position.

In those trials when the antenna was stopped and the A-scope used (Run III), the range step was always on, and the SG operators used only the 75,000 yard scale. The general instructions still remained the same as for Runs I and II. The method of the operators varied only insofar as some obtained the bearing reading first and then focused their attention on the range step, while others started cranking the range as soon as a pip appeared on the A-scope, and then simultaneously cranked range and bearing. No apparent difference in speed or accuracy was noticed by either of these methods. All of the SG operators switched the antenna sweep from automatic to manual as soon as possible after the target appeared.

Constants The following factors were held constant throughout each run: antenna rotation rate; number of targets--one static target on the PPI at any one time; target size--300 yards wide and 6° long; the target to move after every target report by the operator; number of trials--SG operators completed all runs for continuous rotation and a single run with the A-scope on the same day.

Successive targets varied between the following limits: plus and minus 10° in bearing, and plus and minus 5,000 yards in range from the previous setting. Limitations of equipment permitted the use of only one simulated target throughout the experiment. Targets were produced by the SRFL-1 Target Simulator.*

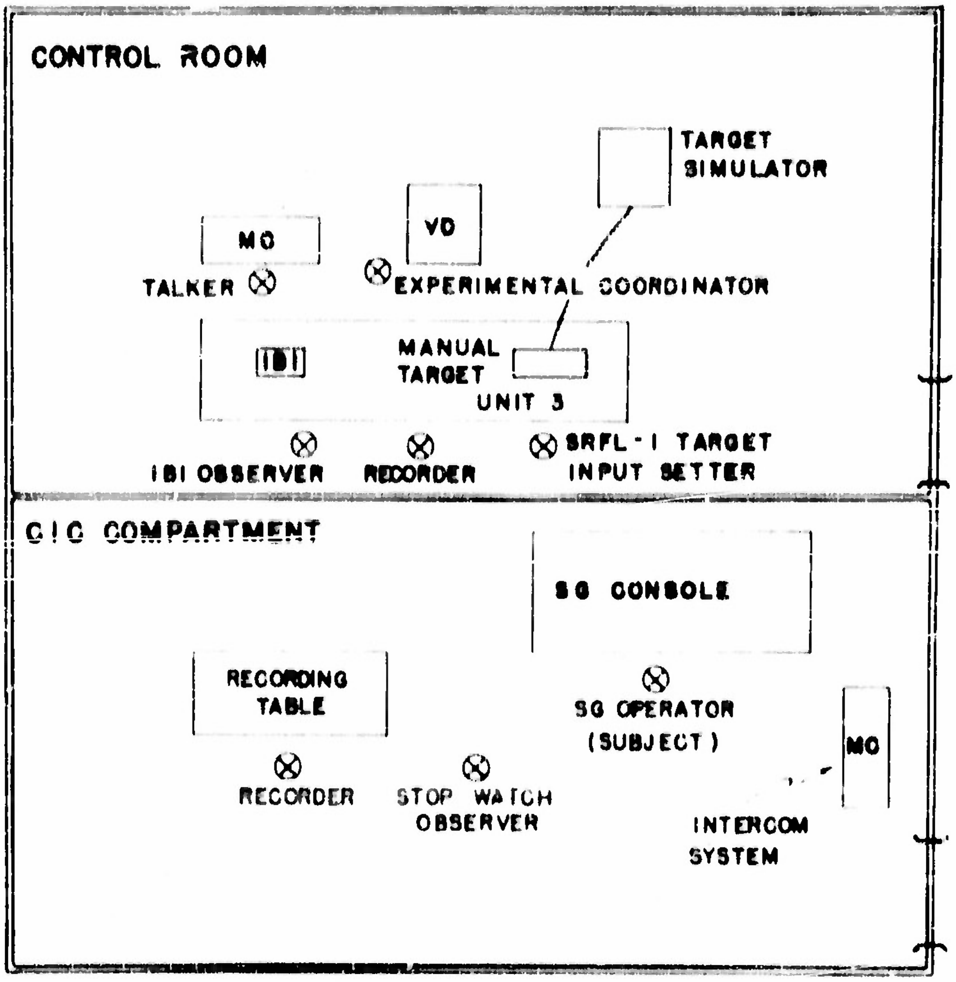

Fig. 2. General layout of equipment and personnel

Recording Procedures Targets were set in as designated by the experiment-coordinator. This experiment-coordinator observed the target and the SG PPI presentation from a VD radar repeater also located in the control room, and directed the target-setter to insert new targets immediately after the sweep of the antenna was 10° past the target already reported by the SG operator. Immediately after

* See Appendix for description of the SRFL Target Simulator.

informing the target-setter to insert a target, the experiment-coordinator informed the SG operator, the time-study observer, and the observer at the Instantaneous Bearing Indicator (IBI)* that a new target would appear. This was done through the intercommunication system. In all cases a 90° lead was provided in order to prepare the SG operator for the next target. Before every run, the target-setter inserted five practice targets.

Time for acquiring and reporting one target was measured in two ways for continuous antenna rotation at the various antenna rates.

Stop-Watch Method — A stop-watch observer on the SG started the Meylan split hand time-study watch when the sweep crossed the target and stopped the second hand upon completion of the report by the SG operator. In that manner the total time to acquire and report a target was obtained.

IBI Method — For the second method of measuring time the Instantaneous Bearing Indicator was used. The IBI is a device which measures the angle displaced by the antenna, and by a computation involving the rpm of the antenna, the degrees displaced are converted into time.

The time values obtained by the Stop-watch and IBI methods were then compared and checked for accuracy. Whenever the difference between the two readings was significant, that particular set of readings was discarded.

For the method of stopping the antenna (Run III), only the Stop-watch method of observing time was used.

LIMITATIONS

The limitations of the experiment were partially due to equipment facilities and partially due to the criteria established to avoid some variable factors from entering into the experiment. The limitations are explained below:

(a) Only one static target was presented on the radar at any one time. The systems Research Field Laboratory at the time had only one of six static simulated targets available with the degree of accuracy required for a study of this type. The accuracy of the simulated target was 0.25% in range and two degrees in bearing.

* See Appendix for description of the IBI.

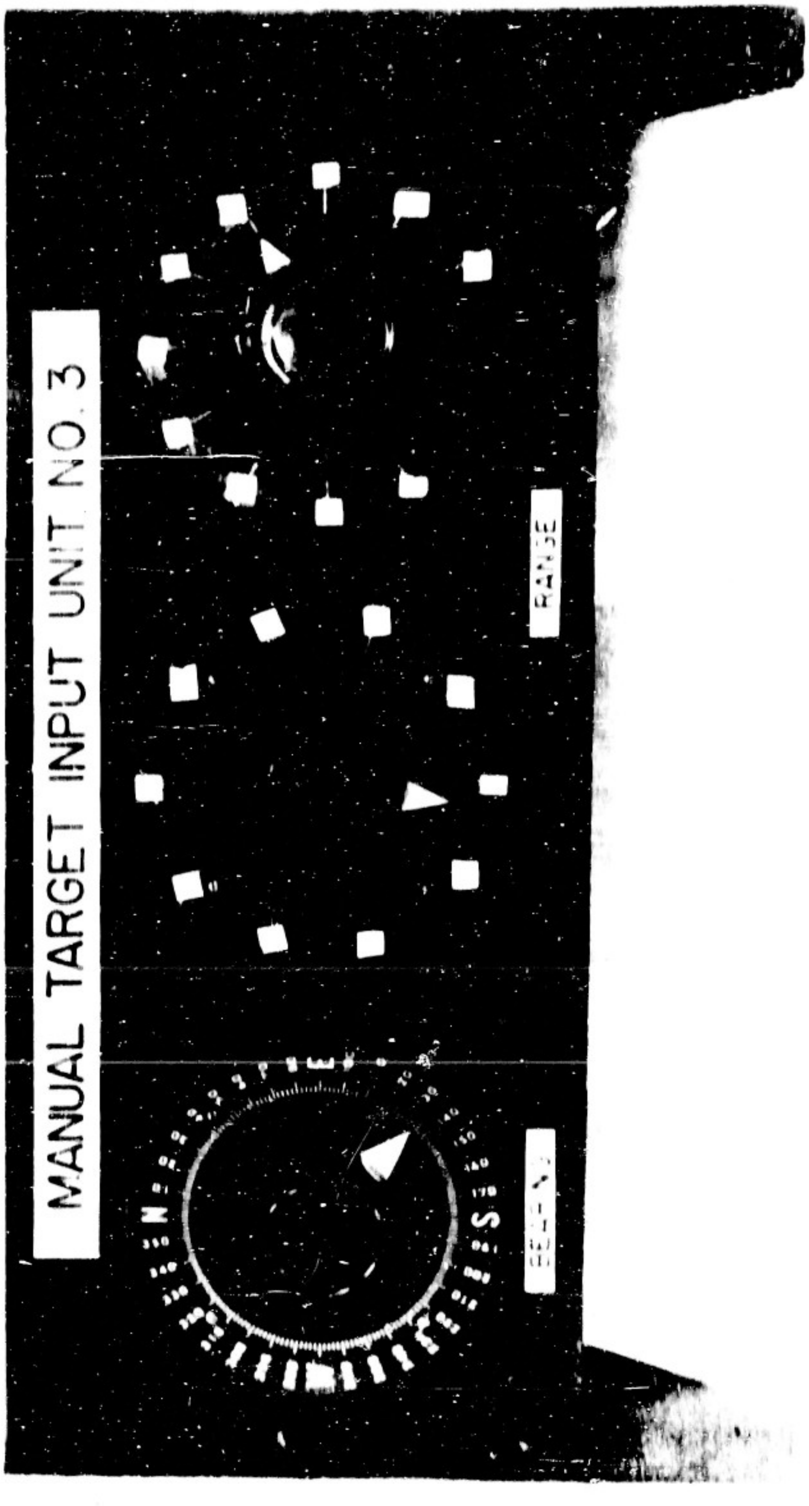

Fig. 3. Manual Target Input Unit for simulating a target on the SG.

(b) It was observed that there were large and variable bearing errors throughout the runs made. The parallax errors were great. Some were caused by a two-inch offset of the bearing cursor in front of the Cathode Ray Tube (PPI scope). Another source of parallax errors was found to be due to the fact that the Cathode Ray Tube is curved while the cursor line is flat. Finally it was discovered that the center of the antenna sweep and the center of the cursor were not coincident. This difference of centers was measured by daily checks, and found to vary between 2,000 and 3,000 yards. Although the technicians tried to make these two center points coincide, this hit-and-miss adjustment could not be perfectly accomplished by electrical and mechanical means. Therefore it was decided that bearing corrections would be applied to the data. Later it was found that the center of the antenna sweep was different from day to day, so that the problem of bearing accuracy should be treated separately.* Hence the remainder of this report will refer to range only, when discussing accuracy.

(c) The range error was computed as the difference between the readings from the SG and from the simulated target input; the latter was assumed to be the true value.

DISCUSSION OF RESULTS

Summary of Data The data in Table I represent the arithmetic means of the five subjects' performances at different antenna rotation rates while operating under the three sets of instructions. These data are also presented in chart form in Fig. 4. Cross-hatched columns represent data for Run I, the blank columns represent data for Run II, and the dotted column represents data for Run III. The heights of these columns indicate the range error which is scaled to the left ordinate of the chart. The time values to acquire and report a target in seconds are shown by the narrow solid black columns placed inside the range error columns to which they correspond. The heights of these black columns indicate performance times and are scaled to the right ordinate.

Range Error Increases with Operator Speed. Fig. 4 shows that the average range error was greater when speed of operation was stressed than when accuracy was stressed.

* Lipschultz, H. L. and Sandberg, K. O. W. A study of alignment errors between the bearing cursor and antenna trace on the PPI of the SG-1b (Mod 50) Radar. Report No. 166-I-20. Industrial Engineering Laboratory, New York University, 1 July 1947. (Restricted)

TABLE I

SUMMARY OF DATA FOR THE FIVE OPERATORS IN RUNS I, II, & III.

		ARITHMETIC MEANS			STANDARD DEVIATION	
		Number of Observations	Time in Seconds	Range Error in Yards	Time in Seconds	Range Error in Yards
4 rpm	Run I	233	28.2	147	5.6	162
	Run II	224	8.1	351	1.6	247
6 rpm	Run I	234	21.8	69	4.2	60
	Run II	230	7.2	301	1.5	263
8 rpm	Run I	232	18.8	125	4.3	101
	Run II	233	6.2	336	0.9	285
12 rpm	Run I	233	14.2	97	3.7	76
	Run II	219	5.8	304	1.1	257
Stop Antenna	Run III	232	9.0	60	0.7	41

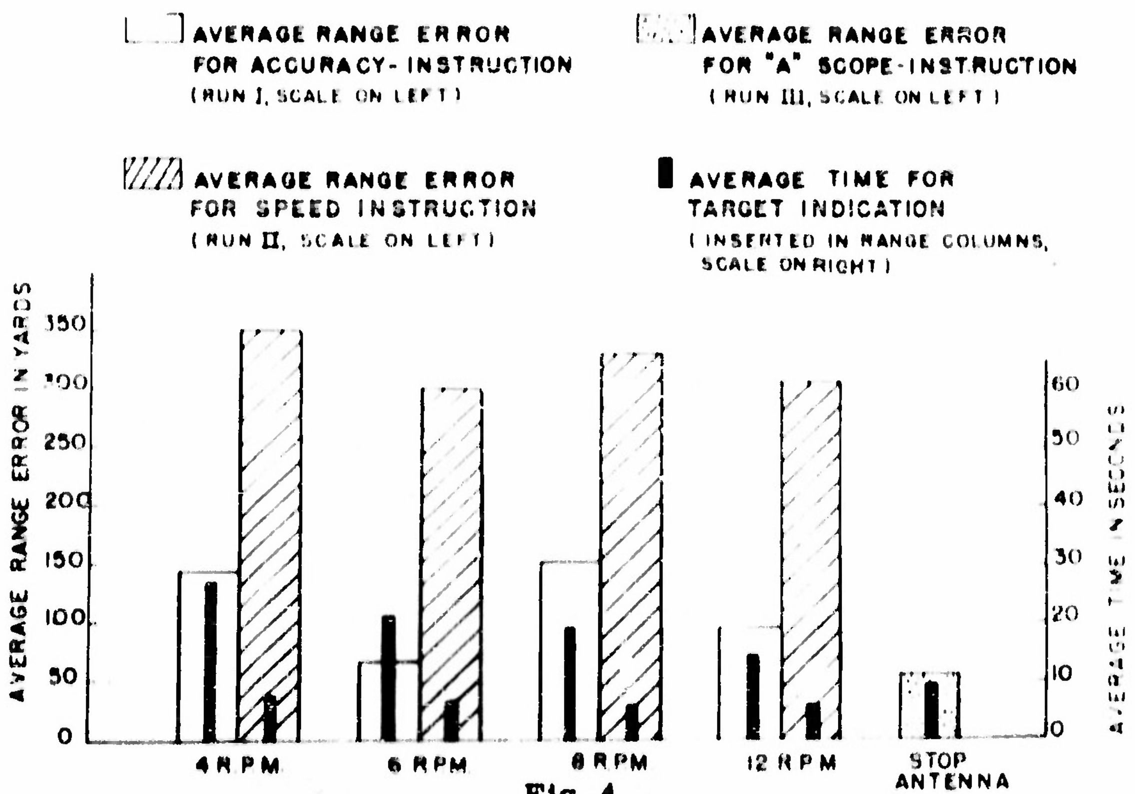

Fig. 4

Working Time Increases with Operator Accuracy. By comparing the combination of values (range errors and time) shown in Fig. 4, one can obtain a conception of the added time required to be more accurate, and of the degree of accuracy if more time is allowed for adjusting the instruments. For example at four rpm, it took 20.1 seconds longer to obtain 204 yards greater accuracy.

Stopping Antenna Permits Greatest Accuracy. Fig. 4 also shows that on the average, the magnitude of error was least when operating under the A-scope instructions (Run III) with stopping the antenna than when operating under the Accuracy instructions (Run I) with continuous antenna rotation. The time to indicate a target is also less for Run III than for Run I. When operating under the Speed Instructions (Run II) the range error is greatest and the time required is less than either Runs I or III. From these data it can be said that the use of the A-scope method gives best accuracy in a reasonable time, the speed being only one to three seconds longer than Run II.

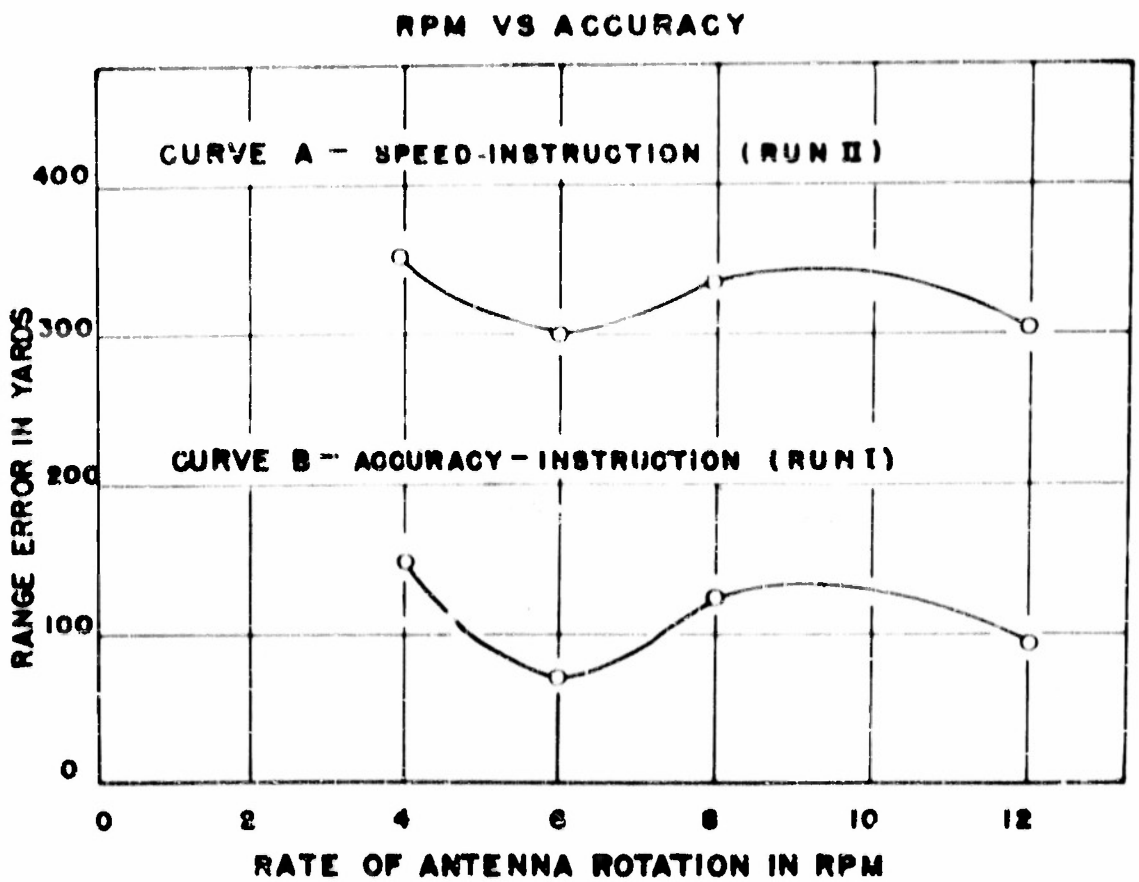

Fig. 5

Influence of Antenna Rotation on Speed and Accuracy

This experiment was specifically set up using four different antenna rotations to determine if the antenna speeds would be a variable factor. This factor does not seem to enter into the average range errors but does affect the time values. Figs. 5 and 6 and Table II show these relationships. Curves A and B in Fig. 5 indicate that there is no systematic relationship between range error for any one set of instructions and the rate of antenna rotation. Accuracy seems to be somewhat better for a rate of six rpm than for any other rate, but this phenomenon appears to be due to some unaccountable constant error.

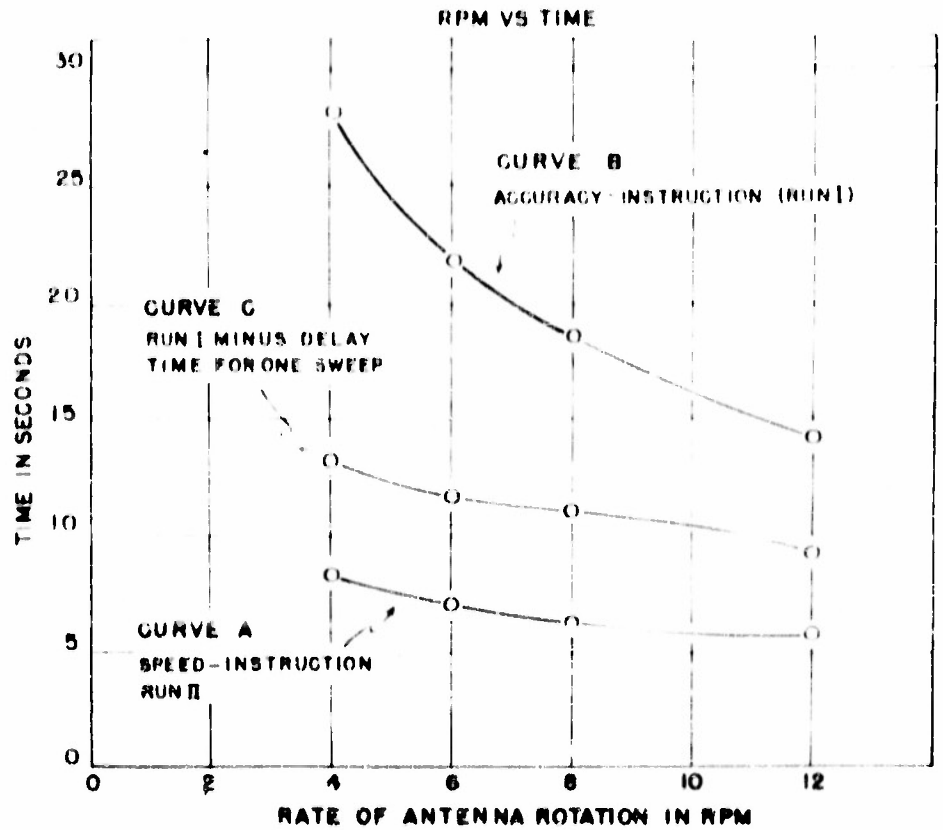

Fig. 6

Difference Between Runs I and II

Regardless of the antenna rate there is a constant difference of 200+ yards in range error between the Speed-instruction and Accuracy-instruction trials. The numerical differences are shown in Table II.

TABLE II

DIFFERENCES OF AVERAGES BETWEEN RUNS I AND II
FOR FIVE OPERATORS AT CONTINUOUS ANTENNA ROTATION

Antenna Rotation Rate	Time Difference (Seconds) (Run I - Run II)	Range Error Difference (Yards) (Run II - Run I)
4 rpm	20.1	204
6 rpm	14.6	232
8 rpm	12.5	211
12 rpm	8.4	207

Time Required at Higher Rates of Antenna Rotation

Curves A and B in Fig. 6 show that there is a relationship between antenna rotation and the time to indicate a target. For Run I (Curve B) the average time varies from 28 seconds for 4 rpm to about 14 seconds for 12 rpm, and for Run II (Curve A), the time difference is small, varying from about 8 seconds at 4 rpm, to 6 seconds at 12 rpm. The greater difference in Run I is due to the operators' waiting for more than one antenna crossing of the target.

Curve C in Fig. 6 demonstrates the effect of the operators' waiting for another sweep. In this case the time interval between two appearances of the target for each rotation rate (15 seconds for 4 rpm, 10 seconds for 6 rpm, 7.5 seconds for 8 rpm, and 5 seconds for 12 rpm) was subtracted from the data of Run I. The result is that the average time diminishes from about 13 seconds at 4 rpm to about 10 seconds at 12 rpm. Curve C (Run I minus delay time for one sweep) then shows an rpm vs. time relationship similar to that of Curve A (Run II).

Variability of Data

Table I also contains the standard deviations of both time and range errors. Standard deviations give an indication of the variability of the data. An illustration of the variability of the time required to obtain and report range and bearing for an operator is shown in Fig. 7. The illustration was taken from the data for Operator B at an antenna rotation of 12 rpm, operating under the instruction that speed was required (Run II). The average time value was 5.2 seconds, and the standard deviation was equal to 0.7 seconds.

The results obtained show an approximately normal distribution for time values about the arithmetic mean, and so one standard deviation represents 68% of all the readings obtained, 95% fall within ± two standard deviations, and 99.7% fall within ± three standard deviations. The distribution for range error values were skewed with the tail extending into greater range errors.

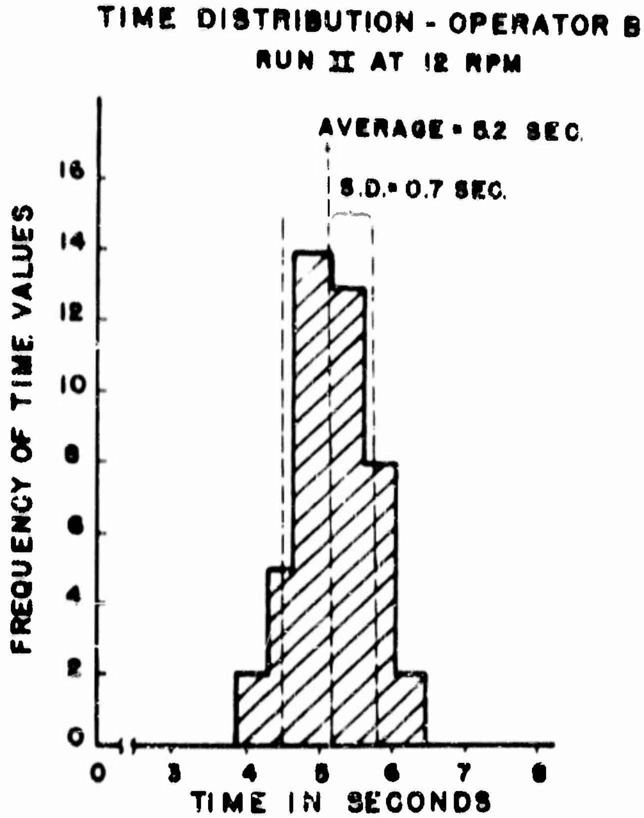

Fig. 7

Spread of Data for Continuous Rotation Table I shows without exception that the standard deviations of the time values for Run I were always greater than those for Run II, and that the standard deviations of the range errors for Run II were always greater than those for Run I. The greater variability of the range errors while operating for accuracy as opposed to those while operating for speed indicate that when an operator takes time to be more accurate, his errors will vary less among themselves than if he were instructed to operate rapidly and depend upon his own judgment in obtaining the correct readings. In other words, when one guesses at the correct range of a target his errors will vary in greater amounts than if he were to use mechanical methods to assist him in determining the correct range.

Spread of Data for Stopping Antenna Table I also shows that the variability of errors for Run III is less than the variability of errors for both Runs I and II. This means that when an operator stops the antenna and obtains the reading, his results will vary less than they did when readings were obtained with the antenna in continuous rotation. Fig. 8 gives an illustration of the variability of time and accuracy for the three runs.

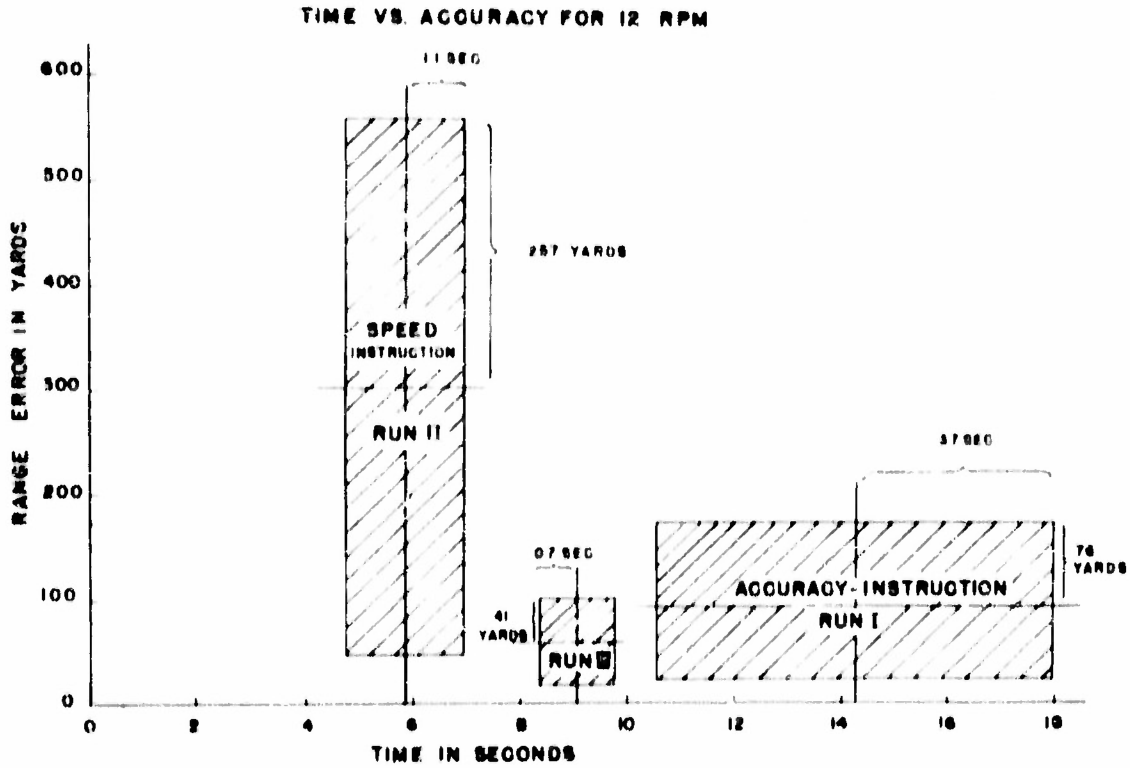

Fig. 8

For continuous antenna rotation, what is the explanation for the fact that when the operator was instructed to operate with emphasis on accuracy he was less consistent in time but more consistent in range error, and just the contrary when he was instructed to operate fast? This can be understood if one realizes that when the operator tries to act rapidly, he will obtain his readings after seeing the antenna sweep across the target once. When he tries to be accurate, he probably will want to see the target two or more times. This suggests analyzing the data to get the relationship between accuracy and the number of times the operator observes the target.

Blips vs. Accuracy Since a target appearing on a PPI is usually called a "blip", the word "blip" will be used in the remainder of the report to mean the target observed after each successive sweep of the antenna trace. The number of blips observed is independent of time and hence of antenna rotation rates and so the range errors observed at different rotation rates can be grouped into one average value. The readings obtained when the antenna was stopped can be considered as an observation for an infinite number of blips.

The result of analyzing the data into the number of blips observed against the corresponding range error is illustrated in Fig. 9. The outstanding fact to be observed is the difference in accuracy obtained between viewing the blip once as compared to two or more times. The average range error for one blip is 319 yards while the average of two, three, and four is 115 yards, giving a difference of 204 yards. It will be noted that this value of 200+ yards is the constant difference in range error between Runs I and II shown in Table II.

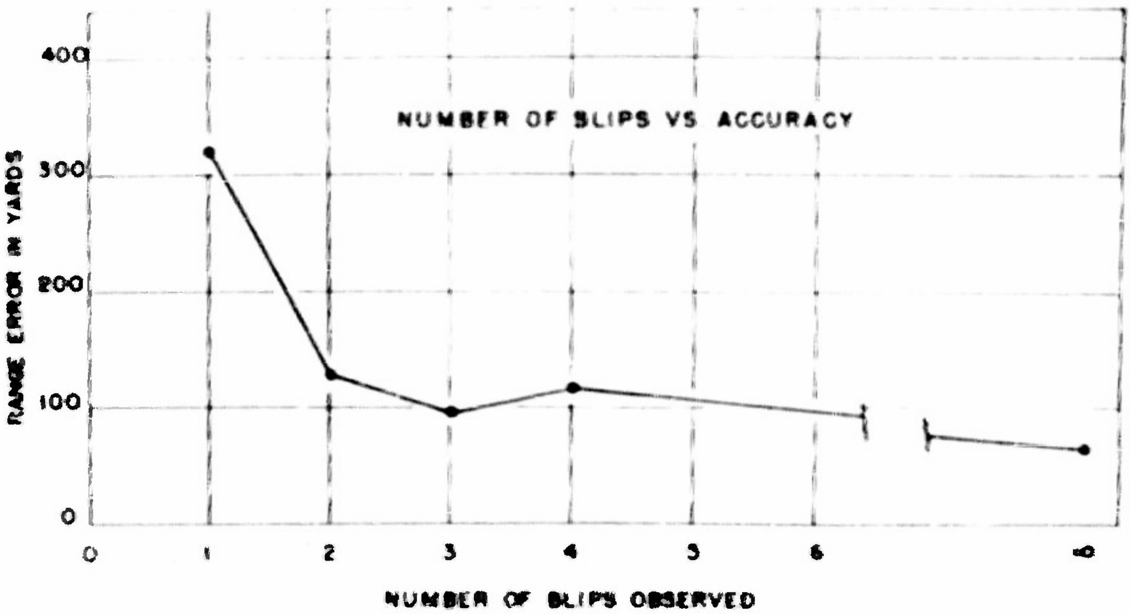

Fig. 9

This brings up the question of the number of blips used by the operators in Runs I and II. Table III shows this breakdown in percentages of the number of times the operators used one, two, three or four blips in Runs I and II for each rate of antenna rotation.

The data tabulated below indicate that the general effect of the instructions was to cause the operators to use one blip for Run II (Speed-instructions) and two or more blips for Run I (Accuracy-instructions). This overall relationship is not so definite for Run II at 12 rpm and Run I at 4 rpm since the time element becomes more important for these extreme cases.

Originally this experiment sought to determine the effect of instructions on speed and accuracy in target indication by use of radar gear. The principal effect of the instructions was to divide the operators into two groups, those that used one blip and those that used two or more blips. As a result, no systematic relations between speed and accuracy were obtained. Other experiments will be necessary to obtain that relation.

TABLE III

TABLE SHOWING DISTRIBUTION OF NUMBER OF BLIPS OBSERVED BEFORE REPORTING

	N	1 Blip (%)	2 Blips (%)	3 Blips (%)	4 Blips (%)
4 RPM					
Run I	233	15.0	61.8	23.2	0.0
Run II	224	100.0	0.0	0.0	0.0
6 RPM					
Run I	234	0.0	61.2	38.0	0.8
Run II	230	100.0	0.0	0.0	0.0
8 RPM					
Run I	232	0.0	46.6	45.7	7.7
Run II	233	92.3	7.7	0.0	0.0
12 RPM					
Run I	233	0.0	39.5	50.2	10.3
Run II	219	79.5	20.5	0.0	0.0
Average for all RPM					
Run I		3.8	52.2	39.3	4.7
Run II		92.9	7.1	0.0	0.0

CONCLUSIONS

Caution. These experiments were based on static targets. The conclusions, therefore, are strictly applicable only to static targets, not moving targets. The movement of targets introduces sources and kinds of error not found with static targets. It is certain, therefore, that the differences would not be the same in amount for moving targets, and it is possible that there might be other departures from the present conclusions. For station-keeping, however, or for targets whose relative movement is very small, the following conclusions seem applicable.

1. The fastest way to be accurate in target indication is to stop the rotation of the antenna when its trace is on the target and to use the A-scope for obtaining the range and bearing of the target.

2. Since stopping the antenna has a number of disadvantages, instructions striving for accuracy should insist that the radar operator observe a minimum of two blips. Approximately 200 yards greater accuracy can be achieved if the operator observes the target more than once. The added time necessary to gain that accuracy is dependent upon the rate of antenna rotation, where in general the faster the antenna rate the faster the target indication.

3. The accuracy obtained for three or four or more blip observations is not a significant improvement over that obtained for two blips; the extra time required is significant however. Hence in the range of antenna rates tested, the optimum condition of good accuracy with least possible time is the use of two target blips.

4. For continuous antenna rotation, the average range error was greater when speed of operation was stressed than when accuracy was stressed. The time to obtain the indications and report increased when the operator attempted to be more accurate. The variability of readings was larger for continuous antenna rotation than for stopping the antenna.

OBSERVATIONS ON SG OPERATION

The results of this experiment indicate that certain equipment modifications of an SG radar could improve operations for faster performance and more accurate readings. These are indicated below.

a. It would be advantageous to have the centers of the antenna sweep and the manual bearing cursor coincident, since the bearing errors observed were inconsistent. This might be achieved by a device by which the PPI scope could be adjusted to enable the technician to center the sweep of the antenna with the center of the manual cursor without opening the console. Perhaps it might be achieved by having the back of the tube suspended on a movable block which can be adjusted through a gearing arrangement by screwdriver adjustment located at the front or side of the console.

b. A device is needed to provide the advantages found in the method of stopping the antenna, but yet operated with the antenna continuously rotating. Such a device is needed because it was found that the most accurate range readings were obtained when the method of stopping the antenna was employed and continuous antenna rotation is necessary for continuous search procedure. This might be done by having two sweeps appear on the PPI, possibly by having two independent antennas, one for continuous rotation and one for stopping.

There are some recommendations which are based on interpretations of this experiment by the investigators, but are not a direct result of the data obtained. These are:

c. A good instruction manual is needed to standardize the method of operation of the SG. A search of the literature has uncovered two sources of instruction:

1) Instructions for the operation of SG radar (Navyships, 903).
2) A preliminary instruction book for Navy Model SG-1/SGA Radar Equipment. (Eng. 167-A).

Neither one of these manuals has been revised for the Modification No. 50, or later modifications. The tentative SG Bulletin No. 70--Navy Modification No. 50--gives an incomplete set of operating instructions. Most of it deals with instructions for modifying the equipment. Definite statements on operating methods for continuous antenna rotation and for stopping the antenna should be included.

d. Standards for either splitting the target or obtaining a reading on the leading edge should be established for both the technicians and the radarmen. At present a difference of opinion and practice exists.

e. An adjustment is needed to make the range trace thinner and the range bug smaller in size, so that the target can be split better than at present. At present the range trace and bug may be as large as, or even larger than a target picked up on the PPI.

f. The range crank gear ratio appeared to be quite small. It was noted that the operator had to crank a relatively long time to move the range bug for any distance on the PPI and range scope. The range crank-range bug gear ratio should be greater to reduce cranking time. Sensitivity of adjustment, however, should not be lost in the change.

g. The range counter should be located closer to the PPI. at present the center of the range counter is about 15 inches away from the PPI, and the operator has to twist his body away from the PPI to read the range counter.

h. The bearing cursor crank should be moved closer to the manual antenna crank. On the Mod 50, the bearing cursor crank is so located that the operator has his right hand across his body to reach the crank, throwing his body into an uncomfortable position. This puts an undue strain on the operator's back and adds to operator fatigue.

i. The bearing cursor should be curved to fit the contour of the PPI tube. The present bearing cursor specifications call for a flat scribed line, and the cathode ray tube of the PPI is curved.

j. Further experimentation at higher rates of antenna speeds should be undertaken to determine if speed and accuracy can be further improved. The equipment at Systems Research Field Laboratory has not been operating at higher than 12 rpm and therefore such an investigation could not be made.

APPENDIX A: SRFL TARGET GENERATOR

A description of the SRFL Target Simulator used in the experiment follows: (taken from an internal report of the SRFL Simulator by J. J. Faran, Jr.)

"The SR adapter, an adjunct to the SP Trainer, has been rebuilt as a complete target simulator unit and renamed the SRFL #1 Simulator. It generates a synthetic target signal, which is variable in pulse length from about two to six microseconds, and also variable in beam width from about four to 30 degrees. The targets are generated with a maximum range of 80 miles. The SRFL Simulator will generate triggers at 400, 600, or 800 cycle repetition rates, or will operate by receiving triggers from a radar at any repetition rate up to 800 cycles. It will operate at any antenna rotation rate up to 12 rpm. The present performance indicates that the target position accuracy may be better than .25% in range and two degrees in bearing.

"A manual control unit is used to insert the range and bearing desired. The range section of the unit has two dials with necessary gears to a 10 turn helipot to allow both coarse and fine setting of the range pointer. The bearing section of the unit is set up on a single dial which is divided up into 360 degrees. Fig. 3 is a photograph of the manual control unit, showing a maximum range of 50,000 yards."

The target simulated by the SRFL Simulator in this experiment was adjusted when necessary to present a target 300 yards in depth, and six degrees long.

APPENDIX B: INSTANTANEOUS BEARING INDICATOR

A description of the IBI used in this experiment follows: (taken from a memo on characteristics of instantaneous bearing indicators by Bartlett, Reed, and Faran, of 24 May 1946)

"The Instantaneous Bearing Indicator comprises an IF synchro with a 2-3/8 inch, 360 degree calibrated aluminum dial mounted on a small stand. The IF synchro is connected in the usual manner to the SG antenna synchro information source. A double pole pedal switch is connected in series with two of the stator leads, so that when the switch is depressed, the instantaneous bearing indicator follows normally, and when the switch is released, it stops. This is shown schematically in Fig. 1. The device takes advantage of the fact that the SG antenna rotates at a constant speed. Thus the angle through which the antenna moves (may) serve as a time measure; when the bearing of a target is known, the time for reporting the details of that target may be determined by subtracting the target bearing from the bearing of the antenna at the instant the report is completed."

For this experiment, one operator was detailed to stop the IBI at the completion of the subject's report, and take a reading of the bearing indicated on the IBI scale. He also kept a close watch to determine if there was more than one revolution. A recorder was stationed alongside of the IBI operator to record the information.

In analyzing the data, the difference between the input target bearing and completion-of-report bearing, including any total revolutions, gave the number of degrees difference between the antenna when it crosses target and the completion of report. When operating at four rpm, the degrees difference was divided by 24 to give the time in seconds for speed of obtaining and reporting target. A constant check on the true rate of antenna rotation was kept at all times.